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ABSTRACT

Despite the fact that increasingly large percentages of Hispanic individuals are being admitted into college programs, the academic success of the students admitted is considerably lower than their non-minority peers. This study focused on the examination of possible causes for the differences in academic performance at the college level for pupils majoring in mathematics and science-related subjects. Forty-nine of the pupils selected were Hispanic bilinguals; the remaining non-minority 53 monolinguals served as a control group. The following three variables were investigated as possible causes for the different achievements of the two groups: (1) academic preparation; (2) motivational factors; and (3) social and economic status. Survey results indicated vast differences between the two groups in areas such as career counseling, role models, motivation, and traditional social and economic indicators. The key to solving the dilemma of improving the academic performance of Hispanic students is viewed as awareness of and compensation for academic deficiencies. (MP)

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Factors Influencing the Performance
of Bilingual Hispanic Students in
Math and Science Related Areas *†

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Abstract

Results of a survey conducted with college student majoring in math and science-related subjects are presented. 49 of the students were Hispanic bilinguals; the remaining 53 monolinguals served as a control group. Survey results indicate a vast difference between the two groups in areas such as career counseling, role models, motivation, and traditional social and economic indicators.

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INTRODUCTION

Despite the fact that increasingly large percentages of Hispanic individuals are being admitted into college programs today as a result of the increased awareness of the need for equal opportunity education, the academic success of the students admitted is considerably lower than that of their non-minority peers. The difference in performance between Hispanic students and non-minority university students enrolled in math and science-related programs is even larger than that between student groups in other programs, and thus merits special attention, as these fields are in urgent need of qualified minority professionals.

This study focused on the examination of possible causes for the differences in academic performance at the college level of a group of Hispanic technical majors and a control group of non-minority technical majors. We defined academic performance on the basis of college grade point average (GPA), and using this definition found a difference approaching significance in the performance of the two groups we surveyed. Whereas nearly one-third of the Hispanic students were on academic probation, with GPAs below 2.0 on a scale of 4.0=A, only 12% of the non-minority students did as poorly. In addition, upper GPAs of 3.3-4.0 were primarily obtained by the non-minority students, of whom 16% were in this category. Only 4% of the Hispanic students surveyed managed to obtain this degree of academic success.

To what, then, can we attribute this discouraging difference in the academic performances of the two groups? Logically, of course, one should

attempt to assess any possible language proficiency variable when conducting cross-cultural studies between individuals with different native languages. This was done by the Bilingual Research Project through a battery of English and Spanish language proficiency exams, the results of which demonstrated that all but 9 of the 49 Hispanic students surveyed demonstrated equal proficiency in both languages, and were therefore "balanced" bilinguals. This result would seem to indicate that some variable other than language dominance was responsible for the lower academic performance of the Hispanic group.

This report presents the results of the investigation of three variables as possible causes for the different achievements of the two groups:

1. Academic Preparation: Were the academic preparations of the two groups significantly different prior to college matriculation?
2. Motivational Factors: Do the two groups demonstrate different motivations for pursuing careers in math and science-related fields? How were specific motivational factors, such as role models, significant others, and high school counseling, different between the two groups?
3. Social and Economic Status: To what extent do the Social and Economic Status (SES) differences between the two groups influence academic performance?

LIMITATIONS

Like the majority of research currently being conducted in the field of bilingual education, our study suffered from the limitations imposed upon it by not having access to large, well-matched populations of Hispanic and non-minority students. The principal differences between the two groups

were in SES variables, and there are numerous arguments against comparing two populations with a large disparity in SES factors, especially when the populations are also being compared cross-culturally. The large number of such uncontrolled variables makes the interpretation of the data a difficult task, and there is always the danger of apocryphal conclusions.

However, all of our students had one thing in common: they had each chosen, for diverse reasons, to pursue a career in a technical field, defined here as engineering, physics, computer science, or other math and science-related fields. We feel justified, then, not in comparing the two populations in the traditional sense, but in drawing up a profile of the unique characteristics of the Hispanic students who choose to major in technical fields despite the cultural, economic, and language barriers confronting them. Only when a number of such profiles are drawn, through examining a wide variety of Hispanic students enrolled at the college level, can programs be constructed to improve the recruitment, retention, and performance of Hispanic students in the United States.

SUBJECTS

Subjects consisted of two groups, both comprised of students enrolled in technical programs at a major eastern state university. The first group was composed of 49 Hispanic bilinguals; of whom 14 were Freshmen, 17 were Sophomores, 11 were Juniors, and the remaining 7 were Seniors. The majority, namely 32, were engineering majors, while 17 were majoring in computer science, zoology, or other technical fields.

The second group, which served as a norm, consisted of 53 non-minority

students, of whom 8 were Freshmen, 29 were Sophomores, 9 were Juniors, and 7 were Seniors. Like the Hispanic group, the non-minority students were primarily engineering majors; there were 37 engineering majors in this group, with the remaining 16 distributed among computer science, zoology, and other technical programs.

Both groups volunteered to participate in the study and were paid for their time.

INSTRUMENT OF MEASURE

A survey was designed to measure the motivational and attitudinal factors influencing both groups, and to collect data on student academic preparation and social and economic status. The survey was broken up into three distinct parts: Academic Preparation, Motivational Factors, and Social and Economic Status.

Part A: Academic Preparation

The first section of the survey consisted of eight questions related to the student's academic preparation for college. Specifically, the questions in this section concerned the number and rigor of math and science courses completed in high school, high school grade point averages, and favorite high school math and science courses.

Part B: Motivational Factors

The second section of the survey was designed to determine which factors were most influential in the student's decision to pursue studies in a technical field. The students were asked to list their primary reasons for selecting such a career from a choice of three possible reasons, which included encouragement, financial, and personal interest factors. An attempt

was made, through several questions, to examine the possible influence of role models or significant others on the student. That is, students were asked to list people they had known--family members and personal acquaintances--involved in careers similar to those the students had chosen for themselves. Questions related to the counseling students received were also included in this section of the survey, and covered counseling received from both high school staff and parents. Lastly, the student was asked at what age the career choice was made.

Part C: Social and Economic Status

Traditional indicators of social and economic status were gathered through questions on the final part of the survey. However, additional variables conceived to reflect social and economic status were also compiled from questions included in this section. Additional variables included the number and types of "technical" possessions the student owned while living at home, selected from the provided list of 9 items that included televisions, electronic kits, cars, calculators, and other sophisticated toys. Other related variables included student extracurricular activities while in high school, and whether or not students held jobs prior to entering college.

The survey was administered to both groups as one part of a regular testing session conducted by the Bilingual Research Project. Students were provided with an unlimited time period to complete the survey. The survey is included in Table I.

RESULTS

Group Similarities

The answers to each question of the survey were cross-tabulated by ethnicity using an SPSS program, and the resulting chi-squares were evaluated for significance. The answers provided to many of the questions were homogeneous between the two groups. For example, there was little evidence of significant differences in the academic preparation of the Hispanic and non-minority students. The majority of students within each group had completed either three or four mathematics courses, of which algebra was the favorite of most students. The structure of science courses for the two groups was similar as well; that is, equivalent percentages of each population took science courses with laboratories and field trips, and physics was overwhelmingly chosen as the preferred course out of the seven science courses listed on the survey. Further, the high school grade point averages of the two groups showed no significant differences; nearly one-third of each group indicated that they had maintained B+ averages during high school, while a slim percentage of both Hispanic and non-minority students fell in the C-D range in their coursework during those years.

Similarities were also found between the two groups' motivations for pursuing careers in technical fields. Despite the fact that Hispanics are underrepresented in all technical professions, equivalent percentages of each group indicated that they had relatives or friends holding occupations in fields similar to those they had chosen for themselves, while nearly one-third of each group maintained that they knew no one in those fields prior to entering college. A large majority of students in each group demonstrated that their parents had discussed their career choices with them.

Yet another variable the two groups had in common was the small percentage of students' mothers to hold occupations in technical fields. The majority of students in both groups indicated that their mothers held no occupation outside the home, and the few mothers who did work held positions in nontechnical fields. This was the only similarity found when the groups were compared according to Social and Economic Status variables; the many differences are described in the next section.

Group Differences

Although a number of characteristics were found to be similar between the Hispanic and non-minority groups, there were still considerable differences between the two groups that merit examination. These differences, as shown in Table II, were least apparent in the academic preparation of the students. In fact, the groups differed significantly with regard to academic preparation only in the number of science courses completed during junior high and high school. This factor would certainly not, in itself, be responsible for the low percentage of Hispanic students who enroll in, and successfully complete, higher education programs in technical fields, nor for the low performance of Hispanic students while in those programs.

Differences existing in the motivational factors of the two groups were found to be far more significant, on the whole, than were those relating to academic preparation. For example, in a question asking whether or not the student was planning to continue his or her career in a technical field, answers were categorized as "yes," "no," or "unsure," and the 3 by 2 chi-square analysis revealed that almost 17% of the Hispanics had already decided to terminate their studies, while less than 4% of the non-minority

students indicated that they had made that decision. Even though the majority of each group indicated that they had chosen their careers sometime between the ages of 14 and 18, the reasons for doing so were very different for each group. That is, when another 3 by 2 chi-square analysis was performed on a question asking students to list their major reasons for selecting a career in a technical field, we discovered that over 60% of the Hispanic students had selected such a career for "interest only," as opposed to the non-minority students, who indicated that "interest and encouragement" or personal reasons were their main reasons for selecting such careers. Approximately 30% of each group indicated that they were motivated specifically by financial reasons. Responses to another question in the survey, "Did you speak with high school counselors or teachers about your decision to pursue such a career?" revealed that, whereas 74% of the non-minority students had discussed their career plans with high school teachers or counselors, almost 64% of the Hispanic students indicated that they had never received counseling of this kind. This would seem to support our contention that the Hispanic students chose careers in technical fields with little support from official school personnel.

The largest differences between the groups were obtained from the final part of the survey, Part C: Social and Economic Status. A 2 x 2 chi-square analysis across the two groups on family income, with low income defined as less than \$30,000 per year and high income as \$30,000 or more per year, resulted in statistically significant results. Analysis of the responses revealed that, whereas over 61% of the non-minority group came from families with combined per capita incomes of more than \$30,000, less than 32% of the Hispanic students' families were in the same economic category. This dis-

parity in family incomes was also reflected in the number of "technical toys" owned by students in each group. "Technical toys" were defined, for our purposes, as electronic kits, chemistry sets, televisions, cars, calculators, bicycles, power tools, and motorcycles. Each student was asked to mark off which toys he or she had ever owned. A 2 x 2 chi-square analysis between the two groups, using categories of less than or equal to five toys, and more than five toys, resulted in statistically significant differences between the two groups in the expected direction. In fact, a 2 x 2 chi-square analysis of income group by technical toys, for the bilingual group only, showed statistically significant results as well, implying that low income Hispanic students owned fewer such technical toys than high income Hispanic students.

The Hispanic students surveyed also appeared to have suffered disadvantages in obtaining employment prior to enrolling at the university. The statistically significant results on this question, shown in Table II, revealed that less than 45% of the Hispanic students held employment while in high school or during summer months, a considerably smaller percentage than the nearly 75% of the non-minority students who held jobs during that time.

DISCUSSION AND CONCLUSIONS

I would like to summarize some of the results from the survey, and offer some possible interpretations of these results. In conclusion, I will discuss several possible strategies for lessening the differences between the college academic performances of Hispanic and non-minority students in math and science-related areas.

In reviewing the differences between the Hispanic and non-minority groups surveyed in this study, it is disheartening to discover that the fewest differences between the two groups exist when comparing academic preparation. I call this lack of difference disheartening primarily because academic preparation is perhaps more easily remedied than the other two variables discussed here, motivation and social and economic status.

The fact is, however, that the only significant difference in the academic preparation between our two groups was in the number of science courses they had obtained. Since this factor alone could not be responsible for the poor academic performance of Hispanic students at the college level, it need not be discussed at any length. I will only point out that there is an important question still to be answered: do individuals who are interested in science take more science courses in high school, or do adolescents become less inhibited--and more interested--in science as a result of obtaining more science knowledge through the appropriate high school courses? The distinction could be an important one, as we have seen that the majority of Hispanic students surveyed in this study indicated that they had not received counseling from high school teachers or staff regarding career plans. This lack of counseling could translate into fewer Hispanic students receiving the necessary academic preparation in high school to continue on in rigorous subjects in college. Few studies have been done on the "math anxiety" of Hispanic students, but a large variety of studies performed with men and women who are not involved directly in professions or programs of study requiring mathematics indicate that self-perception and confidence greatly influence performance in math and science (Tobias, 1978). Other

studies support our contention that high school guidance counselors can successfully act as "key figures" or role models, and influence minority adolescents to examine previously overlooked career options. Thus motivated, students are often inspired to obtain the necessary preparation for math and science programs at the college level while they are in high school (Ganschow, 1970; Pallone, et al., 1973; Cibrowski, 1980).

Another factor to consider regarding academic preparation is the disparity in the SES between the two groups. Lower-income Hispanic families typically reside in city "communities" with school systems that receive less financial support than do schools in middle-income, non-minority neighborhoods. Thus, the programs in such schools are often inferior, with lower teacher-student ratios and fewer alternative programs. Hispanic students graduating from such schools might not necessarily receive the same academic preparation as would students graduating from middle-income schools, and equivalent high school grade point averages achieved at schools in different communities might not realistically reflect student knowledge.

Results from our questions on student motivation to pursue careers in math and science-related areas demonstrate that both groups of students surveyed were probably influenced to the same extent by role models and significant others, with one important exception: there was a statistically significant difference in the types of occupations held by Hispanic and non-minority students' fathers. This difference could be an especially important one, in light of some recent studies which have found that parental occupation has a considerable influence on adolescent career choice and motivation (Church, 1974; Webster and Fretz, 1978). Children of parents who hold jobs in non-

technical fields are often less aware of opportunities in math and science-related fields, and receive less encouragement from their parents to pursue studies in those fields. Current research on "science literacy" indicates that children who are exposed at an early age to science-related literature and technical toys in the home, such as those items listed in this survey, are more likely to be aware of careers in technical fields (Moore and Moore, 1975; Erlich and Lebold, 1977). The differences in parental occupations and income levels between the two groups could therefore result in a significant difference in the amount of science-related knowledge obtained at home between the two groups as well.

Results from the Social and Economic Status questions on the survey support much of the discussion above. The large disparity in income between the two groups did translate to a significant difference in the number of technical toys owned by each group, and to the higher unemployment rate among the Hispanic students. This raises another interesting question concerning the effect of income on performance: are there significant differences in academic performance between different income subgroups of the same ethnic group? To study this, simple T tests were performed on several academic measures after splitting the bilingual group into low and high income subgroups. The T tests resulted in statistically significant differences ($p < .05$) between the low and high income Hispanics on measures such as college GPA, vocabulary, performance on a word problem exam*, and the mathematics

*For a description of this exam, see Mestre(1981)

section of the Scholastic Aptitude Test. Similar T tests between low income and high income non-minority subgroups revealed no statistically significant differences among any of the academic measures available.

This difference in academic measures between low and high income Hispanics may illustrate the effect of environmental factors upon "school-work intelligence." By "school-work intelligence" we mean the facts, skills, and techniques necessary for a student to successfully perform academic school work. To the extent that a student's overall intelligence can be dichotomized into environmental and physiological factors, it is perhaps safe to assume that bilinguals such as those who participated in this study are at a disadvantage, due to the indirect effects of SES variables. The fact that over 50% of the bilinguals in this study had families with incomes less than \$20,000 per year, whereas only 11% of the non-minority group was in this category, means that bilinguals are perhaps less likely to mature in an environment conducive to the development of "school-work intelligence."

IMPACT OF RESEARCH

While educators can do little to improve the economic and social status of Hispanic college students, steps can certainly be taken toward improving the performance of these students in math and science-related areas.

To begin with, high school teachers and guidance counselors should be made aware of the unique financial, cultural, and motivational barriers confronting Hispanic students, so that these students can be encouraged as early as possible to complete high school courses that will provide them with the academic background necessary for any future career option they might consider. Counselors should also be aware of the rapidly increasing

private and public financial aid packages now available to minority students who wish to enter technical fields, making these fields especially advantageous for the minority student.

Awareness programs have been piloted in several high schools and colleges with women and minorities (DeYoung, 1975; Work and Sloan, 1975; Hager, 1976; Rolle, et al., 1977; Richards, 1978), and have resulted in increased interest by the participants in math and science-related careers. These programs are often simple ones, and cost-effective, usually consisting of minority speakers from various occupational fields who come and spend an afternoon with junior high or high school students in order to provide them with detailed information on certain occupations and how best to prepare for them. Colleges and university summer workshops provide women and minority students with the opportunity to learn about career options in engineering, physics, computer sciences, and other technical fields. Awareness programs such as these often provide the impetus and motivation for students to take the necessary preparatory courses, by providing information and role models in the field. Parents should be well-informed by school staff of the various options open to their children, as parental influence on adolescent career choice can often be a strong motivating factor in itself (Shoffner, 1975).

Upon entering university programs, Hispanic students must be properly counseled regarding coursework and the difficulties involved in "catching-up" when precious academic preparation has not been adequate. Often minority students become discouraged through attempting courses beyond their current academic preparation, resulting in high attrition rates despite increased recruitment. In the case of Hispanic minorities, appropriate assessment tests must be conducted to determine language proficiency at the time they

are matriculated, since language proficiency has been shown to play an important role in solving various types of mathematics problems (Mestre, et. al., 1981; Mestre, 1981).

In summary, then, the answer to solving the dilemma of improving the academic performance of Hispanic students at the university level, especially of those in math and science-related areas, is a complex one, involving a wide variety of variables. The key, though, is awareness: if an Hispanic student is made cognizant of possible stumbling blocks common to bilinguals in general, as well as his or her individual academic deficiencies, then the student can become a better learner by actively trying to compensate for these deficiencies and problems. If, in turn, universities are aware of common problems that could impede the progress of Hispanic technical students, then these problems could be addressed through either counseling, remedial courses, or tutorials. A combined effort such as this should facilitate the progress of these students in technical fields.

TABLE I: STUDENT SURVEY QUESTIONS

Part A: Academic Preparation

1. What science courses did you take in Jr. High/High School?
A. Earth Science D. General Chemistry G. Biology
B. Astronomy E. Organic Chemistry H. Other
C. Physics F. Electronics
2. Did any of your science courses have laboratory work? Which ones?
How often?
3. Did any of your science courses have field trips? Where did you go?
4. What math courses did you take in Jr. High/High School?
A. Arithmetic C. Geometry E. Calculus
B. Algebra D. Trigonometry F. Other
5. What was your grade point average in high school?
A. 3.5-4.0 C. 2.5-2.9 E. 1.5-2.0
B. 3.0-3.4 D. 2.0-2.4
6. Which science course did you do best in? Why?
7. Which math course did you do best in? Why?
8. Do you think you will continue to pursue a career in a technical field? Why or why not?

Part B: Motivational Factors

1. At what age did you first decide to major in a technical field?
A. 5-10 C. 14-18 E. 20+
B. 10-14 D. 18-20
2. What made you decide to major in a technical field? (Check as many as apply to you)
A. Encouragement by parents D. Money
B. Encouragement by friends E. Interest in the career
C. Encouragement by teachers/counselors
3. Are there other people in your family who are involved in your field? How are they related to you?
A. Father C. Sister/Brother E. Grandparent
B. Mother D. Aunt/Uncle F. Cousin

TABLE I: STUDENT SURVEY QUESTIONS (cont.)

Part B: Motivational Factors (cont.)

4. Before coming to college, did you know any people in your field, outside of members of your family?
5. Did any of your Jr. High/High School teachers or counselors discuss a career in the field you're in now with you prior to coming to college?
6. Did your parents discuss this career with you?

Part C: Social and Economic Status Factors

1. What extracurricular activities did you participate in during Jr. High/High School? (Check as many as apply to you)

A. Sports	C. Theater/Music Clubs	E. Volunteer Work
B. Science/Math Clubs	D. A Job to Earn Money	F. Other
2. Have you ever owned any of the following?

A. Electronics Kit	D. Power Tools	G. Car
B. Chemistry Set	E. 3, 5, or 10 Speed Bike	H. Television
D. Electric Train	F. Motorcycle	I. Calculator
3. What were your hobbies during Jr. High/High School?
4. What is your father's occupation?
5. What is your mother's occupation?
6. What is your family's approximate combined income?

A. \$5-10,000	C. \$20-30,000	E. \$40,000+
B. \$10-20,000	D. \$30-40,000	

TABLE II: GROUP DIFFERENCES

Significant Differences Discovered in Three Categories of Comparison: Academic Preparation, Motivational Factors, and Social and Economic Status. Comparisons are between an Hispanic group (N=49) and a non-minority group (N=53).

Question	Category Breakdown	χ^2	df	p
<u>Part A: Academic Preparation</u>				
Number of Science Courses Completed in High School	1) 3 completed science courses or less 2) More than 3 completed science courses	7.58	1	.05
Career Counseling Received in High School	1) Yes 2) No	13.48	1	.0005
<u>Part B: Motivational Factors</u>				
College GPA	1) GPA < 2.0 2) 2.01 < GPA < 2.70 3) 2.71 < GPA < 3.30 4) 3.31 < GPA < 4.0	(approached significance)		
What Made You Decide to Major in a Technical Field?	1) Encouragement and Interest 2) Interest Only 3) Other	15.01	2	.0005
<u>Part B: Social and Economic Status Factors</u>				
Father's Occupation (Categorized by Researcher)	1) Technical 2) Non-technical	8.35	1	.01

TABLE II: GROUP DIFFERENCES (cont.)

Significant Differences Discovered in Three Categories of Comparison: Academic Preparation, Motivational Factors, and Social and Economic Status. Comparisons are between an Hispanic group (N=49) and a non-minority group (N=53)

Question	Category Breakdown	χ^2	df	p
<u>Part C: Social and Economic Status Factors (cont.)</u>				
Family Combined Income	1) \$30,000 per year or less 2) More than \$30,000 per year	7.80	1	.01
Number of Technical Toys	1) 5 or less 2) More than 5	5.91	1	.05
Extra-Curricular Activities while in Jr. High/High School	1) Held a job 2) Never held a job (Prior to entering college)	9.08	1	.005

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